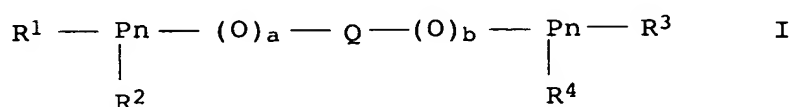


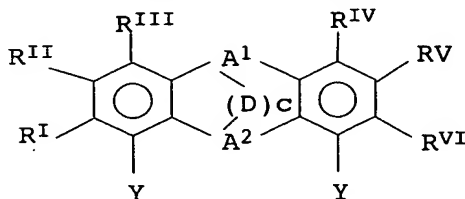
We claim:

1. A process for preparing dialdehydes and/or ethylenically unsaturated monoaldehydes by reacting at least one compound having at least two ethylenically unsaturated double bonds with carbon monoxide and hydrogen in the presence of a hydroformylation catalyst comprising at least one complex of a metal of transition group VIII with at least one ligand selected from among chelating pnictogen compounds of the formula I,



where

Q is a bridging group of the formula



where

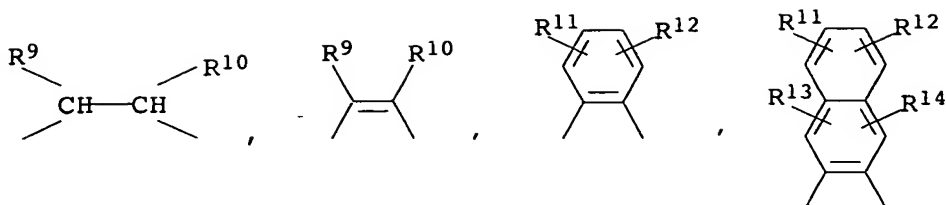
A¹ and A² are each, independently of one another, O, S, SiR^aR^b, NR^c or CR^dRe, where

R^a, R^b and R^c are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl,

R^d and R^e are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl or the group R^d together with a further group R^d or the group R^e together with a further group R^e form an intramolecular bridging group D,

D is a divalent bridging group selected from among the groups

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where

10 R^9 and R^{10} are each, independently of one another, hydrogen, alkyl, cycloalkyl, aryl, halogen, trifluoromethyl, carboxyl, carboxylate or cyano or are joined to one another to form a C_3 - C_4 -alkylene bridge,

15 R^{11} , R^{12} , R^{13} and R^{14} are each, independently of one another, hydrogen, alkyl, cycloalkyl, aryl, halogen, trifluoromethyl, COOH, carboxylate, cyano, alkoxy, SO_3H , sulfonate, NE^1E^2 , alkylene- $NE^1E^2E^3X^-$, acyl or nitro,

20 c 0 or 1,

Y is a chemical bond,

25 R^I , R^{II} , R^{III} , R^{IV} , R^V and R^{VI} are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl, hetaryl, $COOR^f$, $COO-M^+$, SO_3R^f , SO_3M^+ , NE^1E^2 , $NE^1E^2E^3X^-$, alkylene- $NE^1E^2E^3X^-$, OR^f , SR^f , $(CHR^9CH_2O)_xR^f$, $(CH_2N(E^1))_xR^f$, $(CH_2CH_2N(E^1))_xR^f$, halogen, trifluoromethyl, nitro, acyl or cyano,

30

where

R^f , E^1 , E^2 and E^3 are identical or different radicals selected from among hydrogen, alkyl, cycloalkyl and aryl,

35

R^9 is hydrogen, methyl or ethyl,

M^+ is a cation,

40

X^- is an anion, and

x is an integer from 1 to 120,

or

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two adjacent radicals selected from among R^I, R^{II}, R^{III}, R^{IV}, R^V and R^{VI} together with two adjacent carbon atoms of the benzene ring to which they are bound for a fused ring system having 1, 2 or 3 further rings,

5

a and b are each, independently of one another, 0 or 1,

Pn is a pnicogen atom selected from among the elements phosphorus, arsenic and antimony,

10

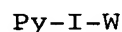
and

15

R¹, R², R³, R⁴ are each, independently of one another, hetaryl, hetaryloxy, alkyl, alkoxy, aryl, aryloxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, heterocycloalkoxy or an NE¹E² group, with the proviso that R¹ and R³ are pyrrole groups bound via the nitrogen atom to the pnicogen atom Pn

20

or R¹ together with R² and/or R³ together with R⁴ form a divalent group E of the formula



25

where

Py is a pyrrole group which is bound via the pyrrole nitrogen atom to the pnicogen atom Pn,

30

I is a chemical bond or O, S, SiR^aR^b, NR^c, substituted or unsubstituted C₁-C₁₀-alkylene or CR^hRⁱ,

W is cycloalkyl, cycloalkoxy, aryl, aryloxy, hetaryl or hetaryloxy,

35

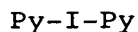
and

R^h and Rⁱ are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl,

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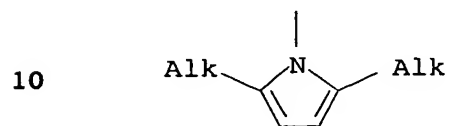
or R¹ together with R² and/or R³ together with R⁴ form a bispyrrole group of the formula

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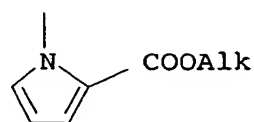


bound via the nitrogen atoms to the pnictogen atom Pn.

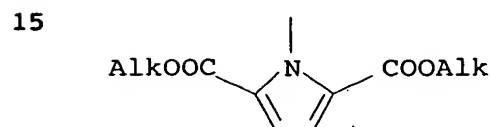
2. A process as claimed in claim 1, wherein at least one ligand of the formula I, in which the radicals R^1 , R^2 , R^3 and R^4 are selected independently from among groups of the formulae I.a to I.k



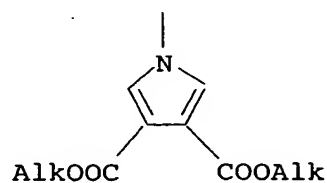
(I.a)



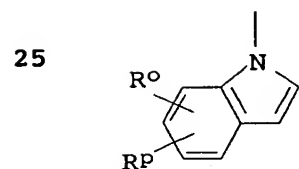
(I.b)



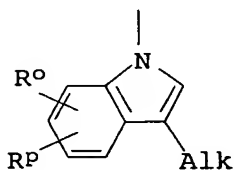
(I.c)



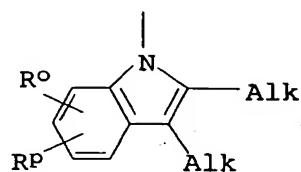
(I.d)



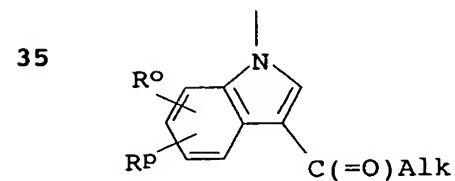
(I.e)



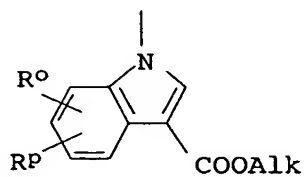
(I.f)



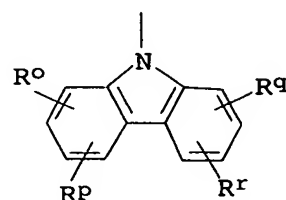
(I.g)



(I.h)



(I.i)



(I.k)

where

45 Alk is a C₁-C₄-alkyl group and

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R^O , R^P , R^Q and R^F are each, independently of one another, hydrogen, C_1 - C_4 -alkyl, C_1 - C_4 -alkoxy, acyl, halogen, trifluoromethyl, C_1 - C_4 -alkoxycarbonyl or carboxyl, is used.

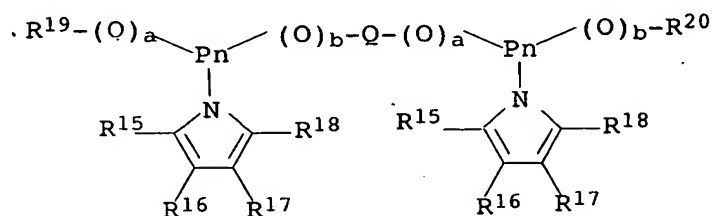
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3. A process as claimed in claim 2, wherein at least one ligand of the formula I, in which the radicals R^1 , R^2 , R^3 and R^4 are each, independently of one another, a 3-alkylindolyl group, preferably a 3-methylindolyl group, is used.

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4. A process as claimed in any of the preceding claims, wherein the chelating pnictogen compound of the formula I is selected from among chelating pnictogen compounds of the formula II,

15



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(II)

25

where

R^{15} , R^{16} , R^{17} and R^{18} are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl, hetaryl, $W'COOR^k$, $W'COO-M^+$, $W'(SO_3)R^k$, $W'(SO_3)^-M^+$, $W'PO_3(R^k)(R^1)$, $W'(PO_3)^{2-}(M^+)_2$, $W'NE^4E^5$, $W'(NE^4E^5E^6)^+X^-$, $W'OR^k$, $W'SR^k$, $(CHR^1CH_2O)_yR^k$, $(CH_2NE^4)_yR^k$, $(CH_2CH_2NE^4)_yR^k$, halogen, trifluoromethyl, nitro, acyl or cyano,

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where

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W' is a single bond, a heteroatom or a divalent bridging group having from 1 to 20 bridge atoms,

R^k , E^4 , E^5 , E^6 are identical or different radicals selected from among hydrogen, alkyl, cycloalkyl and aryl,

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R^1 is hydrogen, methyl or ethyl,

M^+ is a cation equivalent,

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X^- is an anion equivalent and

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y is an integer from 1 to 240,

where two adjacent radicals R^{15} , R^{16} , R^{17} and R^{18} together with the carbon atoms of the pyrrole ring to which they are bound may also form a fused ring system having 1, 2 or 3 further rings,

with the proviso that at least one of the radicals R^{15} , R^{16} , R^{17} and R^{18} is not hydrogen and R^{19} and R^{20} are not joined to one another,

R^{19} and R^{20} are each, independently of one another, cycloalkyl, heterocycloalkyl, aryl or hetaryl, or R^{19} together with R^{15} or R^{16} and/or R^{19} together with R^{17} or R^{18} form a divalent group

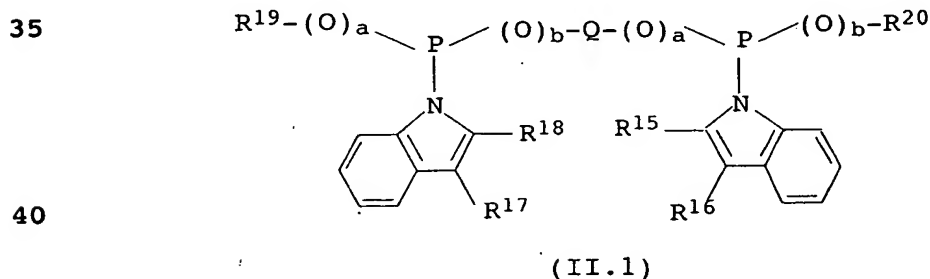
-I-W-

where

I is a chemical bond or O, S, SiR^aR^b , NR^c or substituted or unsubstituted C_1 - C_{10} -alkylene, preferably CR^hR^i , where R^a , R^b , R^c , R^h and R^i are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl and

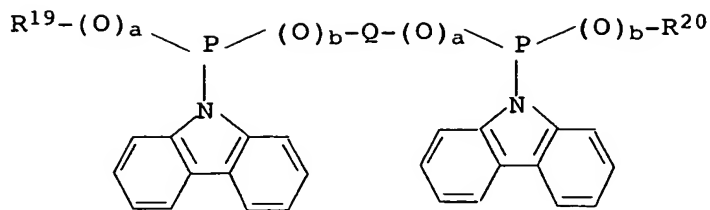
W is cycloalkyl, cycloalkoxy, aryl, aryloxy, hetaryl or hetaryloxy.

5. A process as claimed in any of the preceding claims, wherein the chelating pnictogen compound of the formula I is a chelating pnictogen compound of the formulae II.1 to II.3,

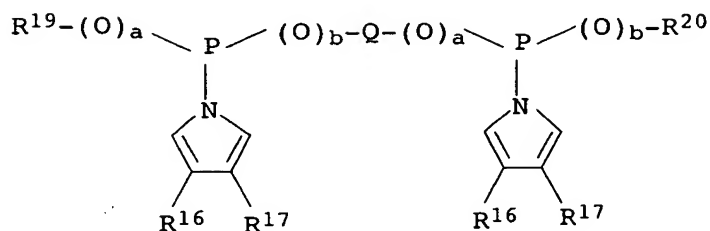


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(II.2)



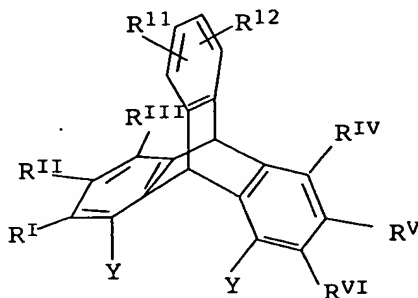
(II.3)

where

R^{15} , R^{16} , R^{17} , R^{18} , Q , a and b are as defined in claim 4, where at least one of the radicals R^{16} and R^{17} in the formula II.3 is not hydrogen,

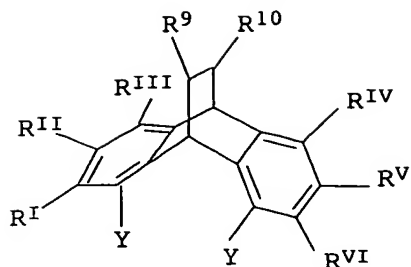
R^{19} and R^{20} are each, independently of one another, cycloalkyl, heterocycloalkyl, aryl or hetaryl.

6. A process as claimed in any of claims 1 to 5, wherein the bridging group Q is a triptycenediyl group of the formula



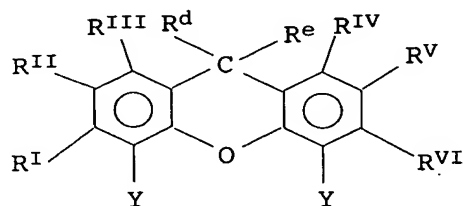
or the formula

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10 where R^I, R^{II}, R^{III}, R^{IV}, R^V and R^{VI}, R⁹, R¹⁰, R¹¹ and R¹² are as defined in claim 1.

7. A process as claimed in any of claims 1 to 5, wherein the bridging group Q is a xanthenediyl group of the formula



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20 where R^I, R^{II}, R^{III}, R^{IV}, R^V and R^{VI} and Y are as defined in claim 1 and R^d and R^e are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl.

25 8. A process as claimed in any of the preceding claims, wherein a molar ratio of ligand to metal of transition group VIII of from 1:1 to 1000:1 is set in the reaction mixture.

9. A process as claimed in any of the preceding claims, wherein the reaction is carried out at from 40 to 80°C.

35 10. A process as claimed in any of the preceding claims, wherein the compound having at least two ethylenically unsaturated double bonds which is used is a α,ω -diolefin.

40 11. A process as claimed in any of the preceding claims, wherein

(i) a compound having a least two ethylenically unsaturated double bonds is subjected to the hydroformylation reaction in a reaction zone,

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(ii) an output is taken from the reaction zone and is fractionated to give a fraction enriched in unsaturated monoaldehydes and a fraction depleted in unsaturated monoaldehydes, and

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(iii) the fraction depleted in unsaturated monoaldehydes is recirculated, if appropriate after work-up, to the reaction zone.

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